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Vilakkumadathil

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(54) **VALIDATING CODE OF AN EXTRACT, TRANSFORM AND LOAD (ETL) TOOL**

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G06F 9/45 (2006.01)
G06F 17/30 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 17/30563*** (2013.01); ***G06F 9/44589*** (2013.01); ***G06F 11/3604*** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

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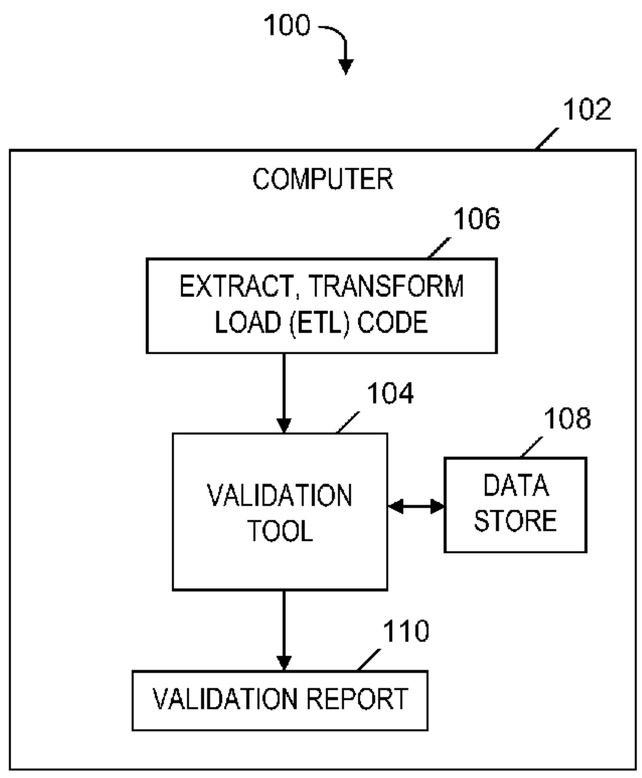
(57) **ABSTRACT**

An approach for validating code for an extract, transform and load tool is provided. Naming, coding, and performance standards for the code are received. The code is exported to a job definition file and parsed. Violations of the standards are determined by a mismatch between the parsed code and the standards. A report identifying the violations is generated. Based on a review of the report and a rework of the code to comply with the standards, the reworked code is exported to another job definition file and parsed, and subsequently is determined to not include the violations of the standards. A second report is generated that indicates the reworked code does not include the violations. An approval of the reworked code is received based on the second report. Based on attributes of a job included in the code, a violation of one of the performance standards is determined.

16 Claims, 6 Drawing Sheets



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G06F 11/36 (2006.01)
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(52) **U.S. Cl.**
CPC ***G06F 11/3612*** (2013.01); ***G06F 11/3616*** (2013.01); ***G06F 17/30371*** (2013.01); ***G06F 17/30377*** (2013.01)

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Amendment filed Aug. 17, 2015 in response to Office Action (Mail Date May 21, 2015) for U.S. Appl. No. 14/331,647; Filing Date Jul. 15, 2014; Confirmation No. 9925.

Notice of Allowance (Mail Date Sep. 10, 2015) for U.S. Appl. No. 14/331,647; Filing Date Jul. 15, 2014; Confirmation No. 9925.

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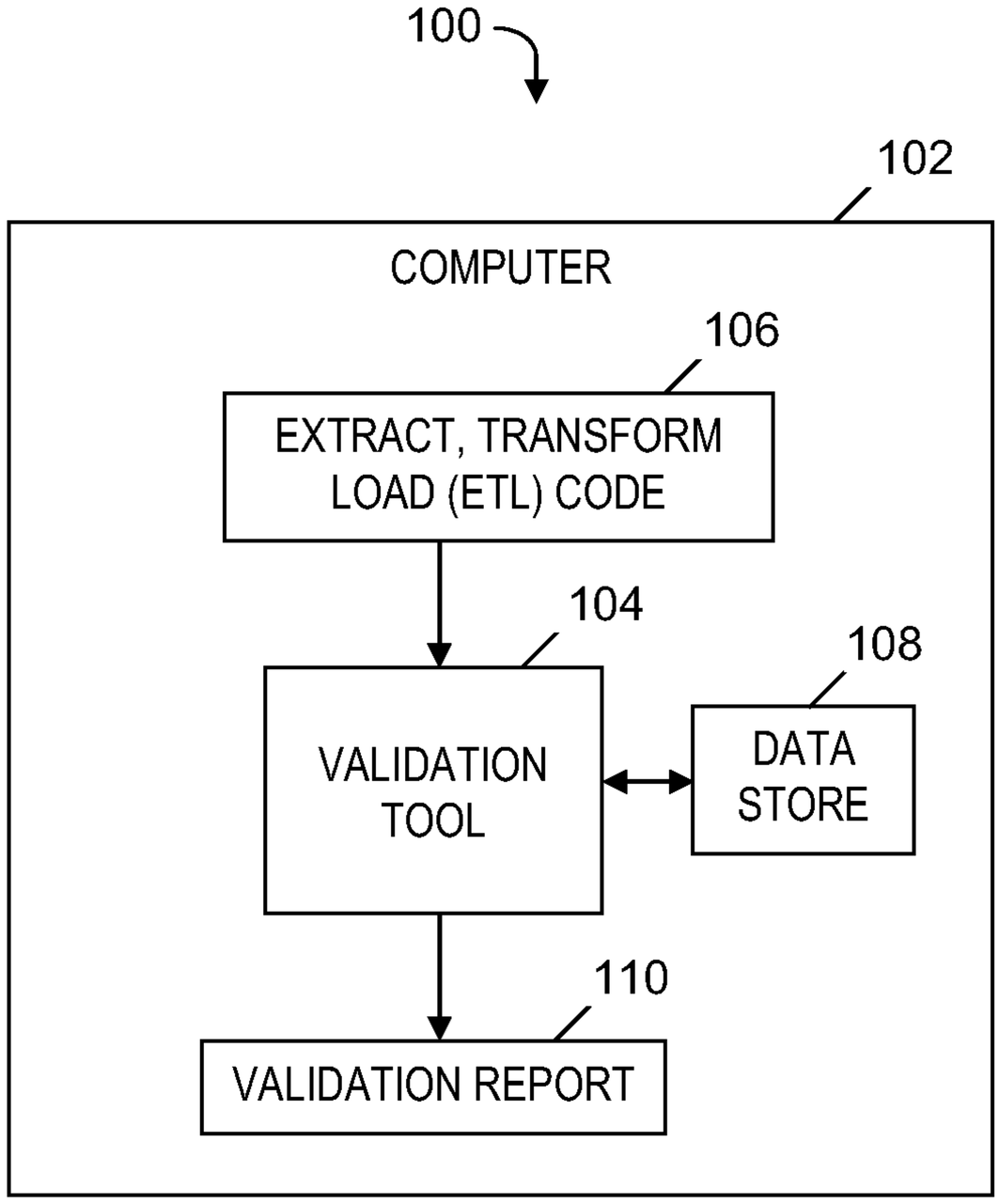
100
102
COMPUTER
106
EXTRACT, TRANSFORM LOAD (ETL) CODE
104
VALIDATION TOOL
108
DATA STORE
110
VALIDATION REPORT

FIG. 1

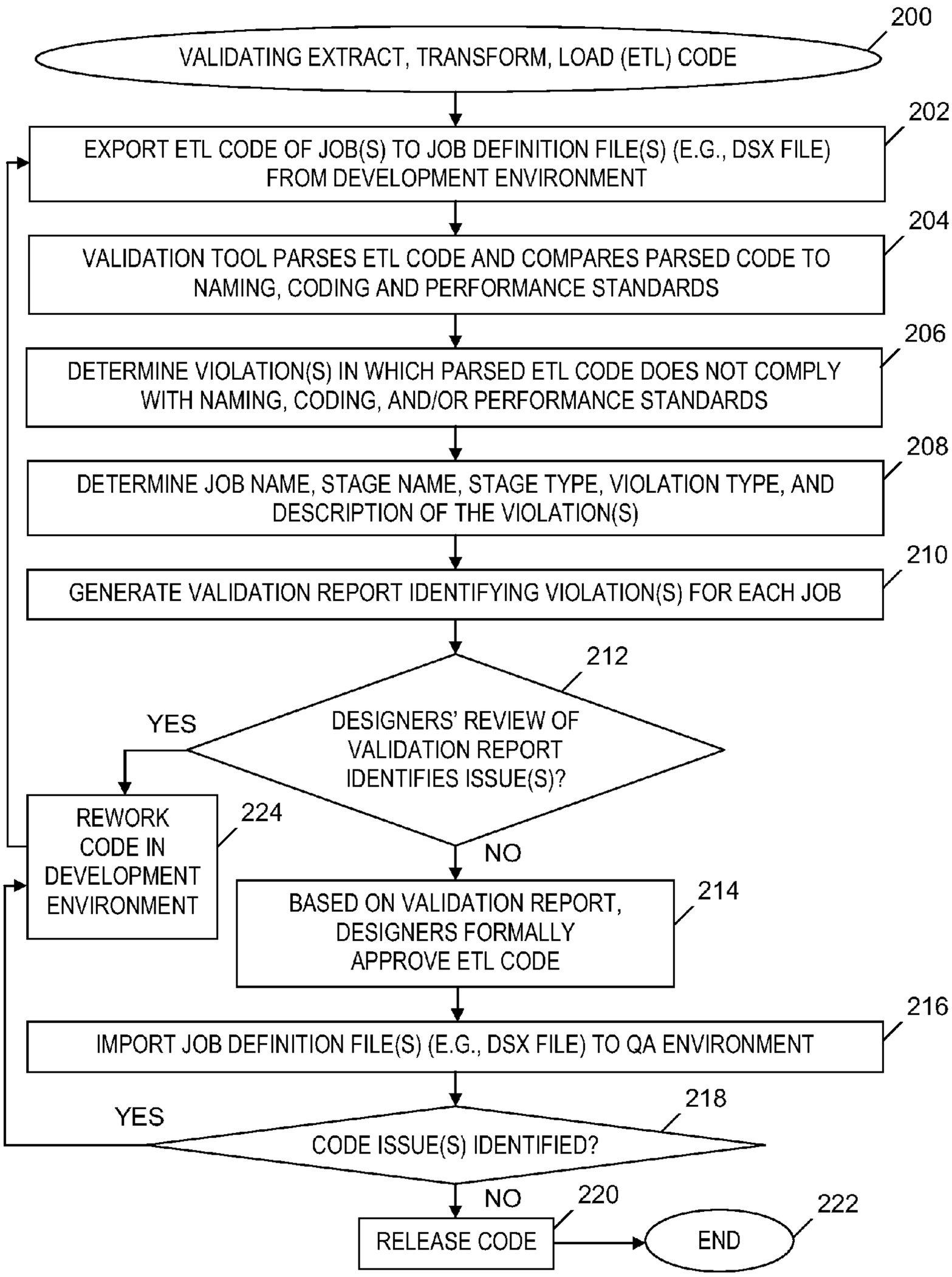
200
VALIDATING EXTRACT, TRANSFORM, LOAD (ETL) CODE
202
EXPORT ETL CODE OF JOB(S) TO JOB DEFINITION FILE(S) (E.G., DSX FILE) FROM DEVELOPMENT ENVIRONMENT
204
VALIDATION TOOL PARSES ETL CODE AND COMPARES PARSED CODE TO NAMING, CODING AND PERFORMANCE STANDARDS
206
DETERMINE VIOLATION(S) IN WHICH PARSED ETL CODE DOES NOT COMPLY WITH NAMING, CODING, AND/OR PERFORMANCE STANDARDS
208
DETERMINE JOB NAME, STAGE NAME, STAGE TYPE, VIOLATION TYPE, AND DESCRIPTION OF THE VIOLATION(S)
210
GENERATE VALIDATION REPORT IDENTIFYING VIOLATION(S) FOR EACH JOB
212
DESIGNERS' REVIEW OF VALIDATION REPORT IDENTIFIES ISSUE(S)?
YES
224
REWORK CODE IN DEVELOPMENT ENVIRONMENT
NO
214
BASED ON VALIDATION REPORT, DESIGNERS FORMALLY APPROVE ETL CODE
216
IMPORT JOB DEFINITION FILE(S) (E.G., DSX FILE) TO QA ENVIRONMENT
218
CODE ISSUE(S) IDENTIFIED?
YES
NO
220
RELEASE CODE
222
END

FIG. 2

300

302

PARALLEL JOBS										
Job Name	…	Agg. Count	Trans. Count	Re-Part. Count	Sort Count	Ann. Count Ratio	DB R/W Count	File R/W Count	Hard-coding Count	Stds. Violation Count
ADS010_Load_ADS…		0	1	0	0	0.75 (4)	1	0	0	0
AIE001WriteSAPFile		8	6	6	7	22 (2)	3	5	0	59
AIE002WriteSAPFile1		0	1	1	1	2 (2)	0	2	0	10
AIS001DataValidation		1	3	0	2	2.25 (4)	4	0	0	28
AIS001EnrichmentAIS…		1	4	7	1	6.2 (5)	9	0	0	36
AIS001ExtractAIS…		0	2	0	0	2.25 (4)	2	3	0	11
…										

304

SEQUENCE JOBS						
Sequence Name	…	Stage Count	Param. Count	Ann. Count	Hard-coding Count	Stds. Violation Count
GEN001LandingFileProcessing		15	7	1	0	23
GEN001StartMonitoringFiles		3	7	1	0	7
GEN004TerminateMasterScript		1	2	1	0	3
…						

FIG. 3

400

DSX Line No.	Object Type	Object Name	Stage Name	Error Description	String Looked For	DSX Line
7192	Parallel Job	ATL201File Receipt	DB_Select_ SIL_CTRL_ Batch_Exec	Database HardCoding	SOL2DEV	<?xml version='1.0' encoding='UTF-16'?> <Properties version='1.1' … <![CDATA[insert into SIL.SIL_CTRL_Batch_Exec(Batch_ID, Business_Date,Job_Start_Date_Time,Job_ End_Date_Time,User_Name,Job_ID,Serial_ No) values (0,CONVERT (date, GETDATE()), {fn NOW()},{fn NOW()},'sol2dev',(select Job_ID from SIL.SIL_CTRL_Job_Defn where Job_Name ='ATL201FileReciept'),NULL)]]> …
7192	Parallel Job	ATL201File Receipt	DB_Select_ SIL_CTRL_ Batch_Exec	Database HardCoding	DWH_D	<?xml version='1.0' encoding='UTF-16'?> <Properties version='1.1' … <![CDATA[insert into SIL.SIL_CTRL_Batch_Exec(Batch_ID, Business_Date,Job_Start_Date_Time,Job_ End_Date_Time,User_Name,Job_ID,Serial_ No) values (0,CONVERT (date, GETDATE()), {fn NOW()},{fn NOW()},'sol2dev',(select Job_ID from SIL.SIL_CTRL_Job_Defn where Job_Name ='ATL201FileReciept'),NULL)]]> …
…						

FIG. 4

500

DSX Line No.	Object Type	Object Name	Stage Name	Stage Type	Violation Type	Violation Description
-1	Parallel Job	AIE001WriteSAPFile	N/A	N/A	Annotation	No Job Annotation
-1	Parallel Job	AIE001WriteSAPFile	XFM_Journal_ID	Transformer	Naming	Stage variable name <Counter> not as per standard - ^sv.*$
...						
63836	Parallel Job	AIS001DataValidation	DB_Upd_AIS_ Journal_Incoming	ODBC_Connector	Record Count	Commit Count (Record Count) should not be less than 3000 [current value : 2000]
63836	Parallel Job	AIS001DataValidation	DB_Upd_AIS_ Journal_Incoming	ODBC_Connector	Array Size	Array Size should not be less than 3000 [current value : 2000]
...						
1976279	Routine [Function]	srDailyMeasures Reconcilation	N/A	N/A	SELECT[ ]+ COUNT[ ]*\ ([ ]**[ ]*\)	Select Statement Ineffective [Select count(*)]
...						
-1	Sequence Job	ATLGEN002 TerminateMaster Script	N/A	N/A	Parameter	Parameter <$APT_GRID_COMPUTENODES> should be present
...						
-1	Shared Container	pscErrorHandling	Container.boError Handling	Others	Auto Partitioning	Auto Partitioning on Link <lkStop>
...						

FIG. 5

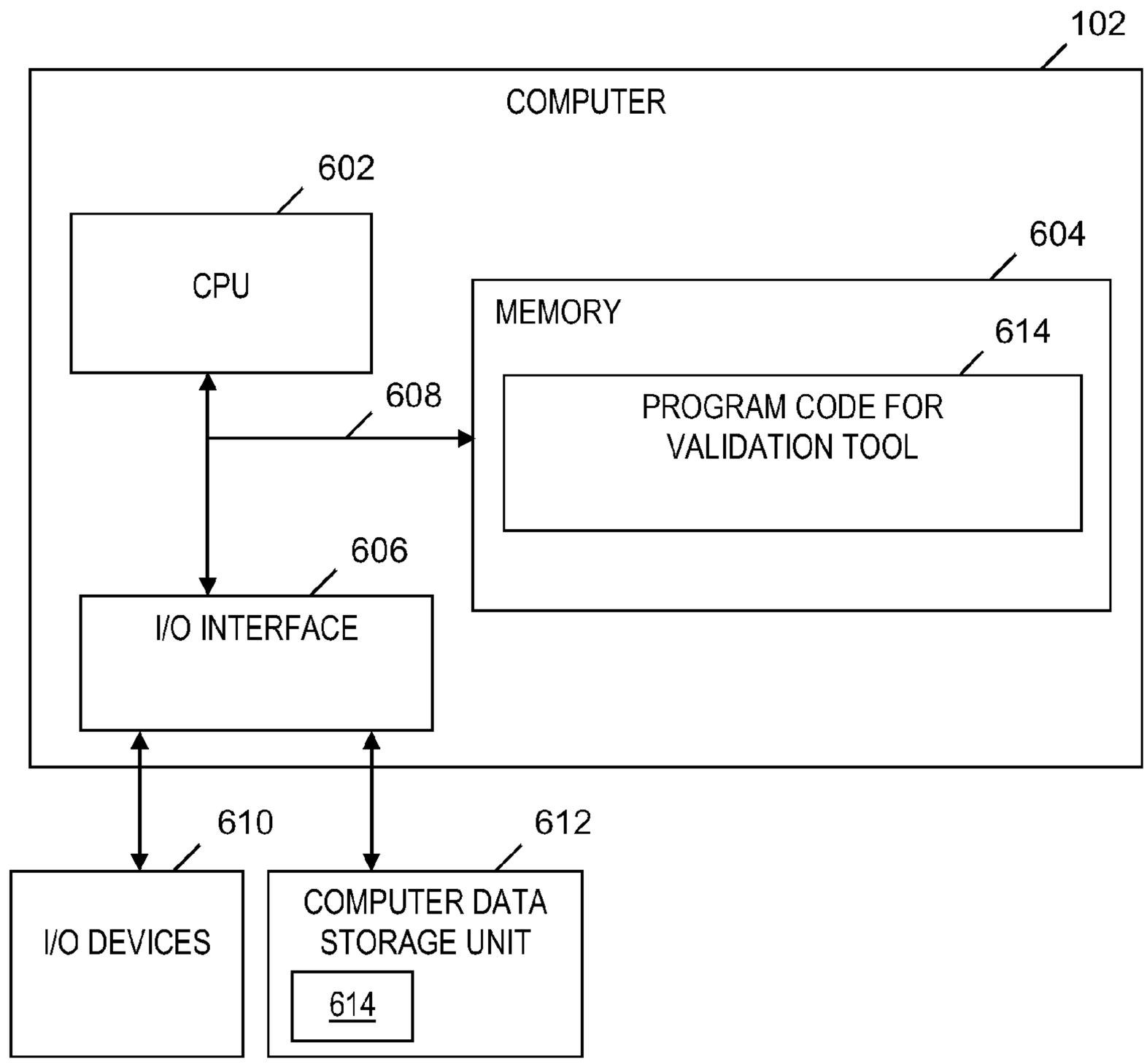
102
COMPUTER
602
CPU
604
MEMORY
614
PROGRAM CODE FOR VALIDATION TOOL
608
606
I/O INTERFACE
610
612
I/O DEVICES
COMPUTER DATA STORAGE UNIT
614

FIG. 6

VALIDATING CODE OF AN EXTRACT, TRANSFORM AND LOAD (ETL) TOOL

This application is a continuation application claiming priority to Ser. No. 14/331,647 filed Jul. 15, 2014, now U.S. Pat. No. 9,244,809, issued Jan. 26, 2016.

TECHNICAL FIELD

The present invention relates to reviewing ETL code, and more particularly to validating ETL code to accelerate review of ETL projects.

BACKGROUND

ETL projects involve complex logic and a large number of jobs and other objects. For example, each project may include 100 to 1000 jobs and other objects. Effective and quality delivery demands disciplined coding. Software developers drawing from different experiences may generate undisciplined coding of low quality. Low quality code has defects and experiences malfunctions, which leads to increased cost and time requirements to rework the code to fix the defects. In the long run, low quality code leads to a lower client confidence in the developers' ability to deliver quality code, which impacts the reputation of the developers. For any project, code quality standards are set before development activities start. The standards specify how to name objects, the best coding practices to be followed, etc. Low quality code still results when developers do not comply with the standards. Not complying with the standards may result from various reasons, including the lack of experience of a developer, the developer being unaware of the relevance of a particular standard and its impact, and/or overlooking a standard by mistake. Overlooking a standard is the most common source of non-compliance with the standards because it is easy for a developer to miss one of the hundreds of standards that may be set for a particular project. Known techniques for addressing non-compliance with the standards are reviews (e.g., peer reviews, group reviews, etc.). Reviews in ETL projects are mostly manual processes. Manual reviews of hundreds of standards are time consuming processes and can be difficult to execute in ETL projects with aggressive timelines. Even if manual reviews are done, reviewers can make mistakes similar to the developers by overlooking some of the standards. With only manual reviews in place, it is difficult to assure a 100% adherence to standards and the quality of deliverables is always at risk.

BRIEF SUMMARY

In a first embodiment, the present invention provides a method of validating code for an extract, transform and load (ETL) tool. The method includes responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code to a job definition file, a computer parsing the code of the ETL tool in the job definition file. The method further includes the computer determining violations of the naming, coding, and performance standards in part by determining the parsed code does not match the naming, coding, and performance standards. The method further includes the computer generating a report which identifies the violations. The method further includes, based at least in part on a review of the report and a rework of the code to comply with the naming, coding and performance standards and responsive to an export of the reworked code to another job definition file, the computer parsing the reworked code in the other job definition file, determining that the parsed reworked code does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code does not include the violations.

In a second embodiment, the present invention provides a computer system including a central processing unit (CPU); a memory coupled to the CPU; and a computer-readable storage device coupled to the CPU. The storage device includes instructions that are executed by the CPU via the memory to implement a method of validating code for an extract, transform and load (ETL) tool. The method includes responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code to a job definition file, the computer system parsing the code of the ETL tool in the job definition file. The method further includes the computer system determining violations of the naming, coding, and performance standards in part by determining the parsed code does not match the naming, coding, and performance standards. The method further includes the computer system generating a report which identifies the violations. The method further includes, based at least in part on a review of the report and a rework of the code to comply with the naming, coding and performance standards and responsive to an export of the reworked code to another job definition file, the computer system parsing the reworked code in the other job definition file, determining that the parsed reworked code does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code does not include the violations.

In a third embodiment, the present invention provides a computer program product including a computer-readable storage device and a computer-readable program code stored in the computer-readable storage device. The computer-readable program code includes instructions that are executed by a central processing unit (CPU) of a computer system to implement a method of validating code for an extract, transform and load (ETL) tool. The method includes responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code to a job definition file, the computer system parsing the code of the ETL tool in the job definition file. The method includes the computer system determining violations of the naming, coding, and performance standards in part by determining the parsed code does not match the naming, coding, and performance standards. The method further includes the computer system generating a report which identifies the violations. The method further includes, based at least in part on a review of the report and a rework of the code to comply with the naming, coding and performance standards and responsive to an export of the reworked code to another job definition file, the computer system parsing the reworked code in the other job definition file, determining that the parsed reworked code does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code does not include the violations.

Embodiments of the present invention provide a tool named "Validation Script" that automatically validates ETL code based on naming, coding, and performance standards and reports violations of the standards, which facilitates effective review of the code in less time. The Validation Script tool described herein facilitates the generation of high quality, disciplined coding for an ETL tool, and traps most code issues before code is delivered from the development environment, thereby decreasing costs involved in rework-

ing code to fix code defects. The reporting of violations includes indicators (e.g., red highlights of standards violations) that allow even non-technical managers to easily monitor the quality of code of an ETL tool. The report also lists configuration details of different objects in a categorized and formatted manner, making the reports detailed and exhaustive. The reports generated will even allow technical experts (who do not have access to the code) to complete a detailed review of the code. Embodiments of the present invention provide processes for an automatic review and a partially manual review of ETL code. The automatic review can provide a 100% savings on review efforts and the partially manual review can provide at least a 50-60% savings on review efforts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a system for validating code of an ETL tool, in accordance with embodiments of the present invention.

FIG. **2** is a flowchart of a process of validating code of an ETL tool, where the process is implemented in the system of FIG. **1**, in accordance with embodiments of the present invention.

FIG. **3** depicts an exemplary portion of a report summarizing violations of standards determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention.

FIG. **4** is an exemplary portion of a report indicating hardcoding violations determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention.

FIG. **5** is an exemplary portion of a report indicating standards violations determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention.

FIG. **6** is a block diagram of a computer that is included in the system of FIG. **1** and that implements the process of FIG. **2**, in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

Overview

Embodiments of the present invention provide automated validation of code in an ETL tool, where the validation is based on determinations of whether the code adheres to predetermined naming, coding and performance standards. The tool "Validation Script" is employed by ETL projects as a review accelerator to determine whether objects developed for the ETL projects adhere to standards and to generate a well-formatted report that indicates which objects adhere to the standards and which objects violate the standards. In one embodiment, the ETL tool that works with Validation Script is IBM® DataStage®, which is an ETL tool offered by International Business Machines Corporation located in Armonk, N.Y. IBM and DataStage are United States registered trademarks of International Business Machines Corporation. Embodiments of the present invention also include a unique "Release Process" with the method described herein, giving a highly robust quality checkpoint for any ETL project.

System for Validating Code of an ETL Tool

FIG. **1** is a block diagram of a system **100** for validating code of an ETL tool, in accordance with embodiments of the present invention. System **100** includes a computer **102**, which executes a software-based validation tool **104** (i.e., Validation Script), which is employed by projects using a software-based ETL tool (not shown) that is executed by computer **102**. In one embodiment, validation tool **104** is employed by ETL projects using the DataStage® ETL tool.

Validation tool **104** receives ETL code **106** in a job definition file which specifies code and attributes of code that includes jobs and other objects of an ETL project. In one embodiment, the job definition file is a flat file in DataStage® Export (DSX) format. Validation tool **104** retrieves naming, coding, and performance standards which are stored in a data store **108** and determines whether ETL code **106** complies with the standards.

The naming standards stored in data store **108** identify valid names in an ETL project, including valid names for jobs, sequences and other objects, parameters and parameter sets, stage variables, and links in jobs and sequences. The performance standards stored in data store **108** enforce (1) limits on usage of expensive stages, including aggregators, sort stages, and transformers; (2) limits on expensive operations, including inline sorting, repartitioning, database read/write operations, and file read/write operations; (3) effectiveness of the performance of queries, including prohibiting select * or select count(*) and enforcing efficient array size and commit count. Annotations standards stored in data store **108** require jobs and sequences to be well annotated. Partitioning-related standards stored in data store **108** prohibit usage of auto partitioning. Parameter constraints configured in validation tool **104** enforce certain parameters to be present or not present on jobs, and enforce standards on the default values specified for parameters. Job activity parameter constraints configured in validation tool **104** enforce standards on values passed to jobs from a sequence job. Other standards stored in data store **108** require: (1) file paths begin with a root path defined at the project level, and (2) surrogate keys are generated in Surrogate Key Generator (SKG) stages and not in Transformer stages.

Validation tool **104** generates a validation report **110**, which includes at least: (1) a summary of a validation of each the jobs and other objects specified by ETL code **106**, (2) hardcoding present in the jobs and other objects specified by ETL code **106**, and (3) standards violations present in the jobs and other objects specified by ETL code **106**. Examples of portions of validation report **110** that include the summary of the validation, the hardcoding, and the standards violations are depicted in FIG. **3**, FIG. **4** and FIG. **5**, respectively.

The aforementioned summary of the validation includes a list of jobs and other objects specified by ETL code **106**. The list of jobs and other objects may be grouped into categories, such as parallel jobs, shared containers, sequence jobs, routines, custom stages, parameter sets, table definitions, etc. The summary includes object-specific information for each job or other object. The object-specific information includes counts of violations for each object, including a count of the number of instances of hardcoding in an object and a count of the number of standards violations included in the object. In one embodiment, the object-specific information includes one or more of: a count of stages, a count of parameters, a count of aggregators, a count of transformers, a count of re-partitioning methods, a count of sorts, a count of annotations, a count of database read/write operations, and a count of file read/write operations.

For example, for each parallel job, the object-specific information includes: (1) date the object was modified, (2) time the object was modified, (3) whether multiple invocations of the same job can be run simultaneously, (4) whether runtime column propagation (RCP) is enabled, (5) whether an after job subroutine is present, (6) whether a before job

subroutine is present, (7) stage count, (8) parameter count, (9) aggregator count, (10) transformer count, (11) re-partitioning count, (12) sort count, (13) annotation count, (14) database read/write count, (15) file read/write count, (16) hardcoding count, (17) standards violation count, and (18) job folder of the job.

Validation tool **104** determines whether the count of an item specified by the object-specific information exceeds a predetermined threshold value stored in data store **108**. If the count exceeds the threshold value, validation report **110** includes a red colored background or other indicator for the count to indicate a violation of standards stored in data store **108**. Furthermore, if validation tool **104** determines that any count of an item of an object exceeds the corresponding threshold value, then validation report **110** includes a red colored background or other indicator for the name of the object. If validation tool **104** determines that the counts of all items for an object do not exceed the corresponding threshold values, then validation report **110** depicts the object without red colored background and any other indicator of a violation to indicate that the object adheres to all naming, coding, and performance standards stored in data store **108**. A reviewer studies validation report **110** to find which objects have and which objects do not have a red colored background or other indication of a standard violation. In this way, the report gives a complete picture on the quality of the code being delivered

For example, if validation tool **104** receives a threshold value of zero for standards violations and determines that the number of standards violations for object XYZ is four, then validation report **110** includes the standards violation count of four with a red background to indicate that four exceeds the threshold value of zero, and includes the name "XYZ" with a red background to indicate that there is at least one violation associated with object XYZ. As another example, if validation tool **104** receives a threshold value of one for the transformer count and subsequently determines that object XYZ includes two transformers, then validation tool **104** generates validation report **110** to include the count of two transformers with a red background to indicate that transformer count of two exceeds the threshold value of one.

The aforementioned hardcoding portion of validation report **110** includes a list of all hardcoding present in the ETL code **106**, which includes a line number in the job definition file (e.g., DSX line number), object type, object name, stage name, error description, the string validation tool **104** searched for in ETL code **106** to determine hardcoding is present, and the line in the job definition file (e.g., DSX line).

The aforementioned standards violation portion of validation report **110** includes a list of all violations of the standards stored in data store **108**, which includes object name, object type, stage name, stage type, and type and description of the violation. For a violation of a naming standard, the list of violations includes the current, non-compliant name of the object along with the expected name of the object which complies with the naming standard.

Validation report **110** may also include one or more of: (1) a list of parameters, defined on jobs and routines specified by ETL code **106**, (2) files used in parallel jobs specified by ETL code **106**, (3) queries in all the parallel jobs specified by ETL code **106**, (4) job activities in every sequence specified by ETL code **106**, (5) a list of after and before subroutines of every parallel job specified by ETL code **106**, (6) a list of details of email activities for every sequence specified by ETL code **106**, (7) a list of expressions from transformers where direct mapping is not present, and (8) job change history. The list of these sheets will grow in next versions of the tool making review easier and complete.

In one embodiment, validation tool **104** (see FIG. **1**) is implemented as a multi-worksheet workbook of a spreadsheet application program, such as Microsoft® Excel® offered by Microsoft Corporation located in Redmond, Wash. Microsoft and Excel are registered trademarks of Microsoft Corporation in the United States and other countries.

The functionality of the components of FIG. **1** is described in more detail in the discussions presented below relative to FIG. **2** and FIG. **6**.

Process for Validating Code of an ETL Tool

FIG. **2** is a flowchart of a process of validating code **106** (see FIG. **1**) of an ETL tool, where the process is implemented in the system of FIG. **1**, in accordance with embodiments of the present invention. The process of FIG. **2** starts at step **200**. Prior to step **202**, computer **102** (see FIG. **1**) receives naming, coding, and performance standards for ETL code **106** (see FIG. **1**) and stores the received standards in data store **108** (see FIG. **1**). The received ETL code **106** specifies job(s) and/or other object(s) of ETL project(s). Hereinafter, in the discussion of FIG. **2**, the received naming, coding, and performance standards are collectively referred to as "the standards."

In step **202**, computer **102** (see FIG. **1**) or another computer (not shown) exports ETL code **106** (see FIG. **1**) to job definition file(s) (e.g., DSX file(s)). Validation tool **104** (see FIG. **1**) receives the exported ETL code **106** (see FIG. **1**) prior to step **204**.

In step **204**, validation tool **104** (see FIG. **1**) parses the ETL code **106** (see FIG. **1**) and compares the parsed code **106** (see FIG. **1**) to the standards to determine whether portion(s) of the ETL code **106** (see FIG. **1**) (1) match character strings or regular expressions specified by the standards, (2) indicate the usage of expensive stages and operations in ETL code **106** (see FIG. **1**) does not exceed predetermined threshold values specified by the standards, (3) indicate effective performance of queries in ETL code **106** (see FIG. **1**), and (4) indicate usage of auto partitioning in ETL code **106** (see FIG. **1**). In one embodiment, in step **204**, validation tool **104** (see FIG. **1**) parses a DSX file into which objects of an ETL project specified by the ETL code **106** (see FIG. **1**) was exported.

The aforementioned match of character strings includes (1) beginning characters of a name of an object matching a predetermined string of characters or a regular expression to indicate a violation of a naming standard, and (2) any portion of ETL code **106** (see FIG. **1**) matching a predetermined string of characters (e.g., matching the string "DWH_D") or a regular expression to indicate an instance of hardcoding. For example, determining that a dataset name does not start with "DS_" indicates a naming standard violation and determining that a portion of ETL code **106** (see FIG. **1**) matches "DWH_D" indicates an instance of hardcoding.

The aforementioned predetermined threshold values indicate limits on attributes of ETL code **106**, where the attributes are associated with the expensive stages and operations. For example, a predetermined threshold value of 1 for an aggregator count means that determining that a job has more than one aggregator indicates a performance standard violation for the job.

The comparison to the standards to determine whether portion(s) of ETL code **106** (see FIG. **1**) indicate usage of auto partitioning determines a standards violation if validation tool **104** (see FIG. **1**) determines that ETL code **106** (see

FIG. **1**) specifies an automatic selection of a partitioning method for a link in ETL code **106** (see FIG. **1**).

The comparison of the parsed code **106** (see FIG. **1**) to the standards also determine whether (1) file paths in ETL code **106** (see FIG. **1**) begin with a root path defined at the project level, (2) surrogate keys in ETL code **106** (see FIG. **1**) are generated only in SKG stages, (3) parameter(s) in a first predetermined set of parameter(s) are present in a job specified by ETL code **106** (see FIG. **1**), (4) parameter(s) in a second predetermined set of parameter(s) are not present in a job specified by ETL code **106** (see FIG. **1**), and (6) a job specified by ETL code **106** (see FIG. **1**) is annotated in a field that describes the job.

In step **206**, validation tool **104** (see FIG. **1**) determines violation(s) in which job(s) and/or other object(s) of the parsed ETL code **106** (see FIG. **1**) do not comply with the standards based in part on the comparison in step **204** determining that portion(s) of ETL code **106** (see FIG. **1**) (1) do not match character strings or regular expressions specified by the standards, (2) indicate the usage of expensive stages and operations in ETL code **106** (see FIG. **1**) exceeds the predetermined threshold values specified by the standards, (3) indicate ineffective performance of the queries in ETL code **106** (see FIG. **1**), and/or (4) indicate ineffective usage of partitioning in ETL code **106** (see FIG. **1**).

In one embodiment, the violation(s) determined in step **206** are also based in part on validation tool **104** (see FIG. **1**) determining (1) a file path in ETL code **106** (see FIG. **1**) does not begin with a root path defined at the project level, (2) a surrogate key in ETL code **106** (see FIG. **1**) is generated in a transformer stage or another stage other than an SKG stage, (3) parameter(s) in the first predetermined set of parameter(s) are present in a job specified by ETL code **106** (see FIG. **1**), (4) parameter(s) in the second predetermined set of parameter(s) are not present in the job, (5) the job is not annotated in a field that describes the job, (6) the field that describes the job does not include a value specified by a job annotation standard, (7) the field that describes the job does not include a name of the job, (8) a job activity in a sequence specified by ETL code **106** (see FIG. **1**) does not pass a value specified by a job activity parameter standard, (9) an add checkpoints feature is not enabled for the sequence, where the add checkpoints feature allows jobs in the sequence to be restartable after a failure of the jobs, (10) a handle activities that fail feature is not enabled for the sequence, where the handle activities that fail feature allows an activity of a failing job in the sequence to be handled by triggering automatically inserted code that branches to an error handling point, (11) a log job errors feature is not enabled for the sequence, where the log job errors feature allows a message to be logged about a job whose run ends with a warning or fatal error, (12) a log job reports feature is not enabled for the sequence, where the log job reports feature allows a status report to be logged after a run of the job, and/or (13) a reset if required then run feature is not enabled for the sequence, where the reset if required then run feature allows the job to be run each time the sequence is run, even after a run of the sequence is aborted.

In one embodiment, the violation(s) determined in step **206** are also based in part on validation tool **104** (see FIG. **1**) determining that (1) a count of the number of aggregator stages of a job specified by ETL code **106** (see FIG. **1**) exceeds a predetermined maximum number of aggregator stages, (2) a count of the number of transformer stages of the job exceeds a predetermined maximum number of transformer stages, (3) a count of the number of occurrences of re-partitioning of data sets in the job exceeds a predetermined maximum number of occurrences of re-partitioning of data sets, (4) a count of the number of sort stages in the job exceeds a predetermined maximum number of sort stages, (5) a count of the number of database read/write operations in the job exceeds a predetermined maximum number of database read/write operations, (6) a count of a number of sequential file read/write operations in the job exceeds a predetermined maximum number of sequential file read/write operations, (7) a ratio of a number of stages of the job to a number of stages of the job that are annotated is less than a predetermined minimum ratio of the number of stages to the number of stages that are annotated, (8) a size of a transaction for an insert, update, or delete operation of the job is less than a predetermined minimum size of the transaction, and/or (9) a size of an array employed for the insert, update, or delete operation of the job is less than a predetermined minimum size of the array. Validation tool **104** (see FIG. **1**) receives the predetermined maximums and minimums described in this paragraph in items (1)-(9) prior to step **206**.

In step **208**, for each violation determined in step **206**, validation tool **104** (see FIG. **1**) determines attributes of the violation, including a corresponding job or object name, stage name, stage type, violation type and description of the violation.

In step **210**, validation tool **104** (see FIG. **1**) generates validation report **110** (see FIG. **1**), which identifies one or both of the following items: (1) object(s) of ETL code **106** (see FIG. **1**) that violate the standards and (2) other object(s) of ETL code **106** (see FIG. **1**) that comply with the standards. The violation(s) of the standards included in validation report **110** (see FIG. **1**) are determined in step **206**. Subsequent to generating validation report **110** (see FIG. **1**), validation tool **104** (see FIG. **1**) sends validation report **110** (see FIG. **1**) to designer(s) for their review. In one embodiment, validation report **110** (see FIG. **1**) is in a spreadsheet format.

In step **212**, designer(s) determine whether their review of the validation report **110** (see FIG. **1**) identifies issue(s) in the ETL code **106** (see FIG. **1**) that need to be corrected or otherwise addressed. Identifying issue(s) in the ETL code **106** (see FIG. **1**) in the review includes determining whether validation report **110** (see FIG. **1**) includes a red colored background (or another predetermined visual indicator of a violation of a standard) for the name(s) of object(s) listed in validation report **110** (see FIG. **1**) and/or for attribute(s) of each of the object(s) which are listed in validation report **110** (see FIG. **1**). An attribute of an object that has the red colored background or other predetermined visual indicator indicates that the attribute causes the comparison in step **204** to determine a violation of the standards. In one embodiment, the review also includes the partially manual and partially automated review described in the section presented below entitled "Partially Manual Review." For example, reviewers go through a "Queries" sheet in validation report **110** (see FIG. **1**) to find all the queries used in the ETL code and to check to see if all the queries have the right clauses.

If none of the objects in validation report **110** (see FIG. **1**) includes the red colored background or other predetermined visual indicator of a standards violation, then ETL code **106** (see FIG. **1**) does not have any issue(s) that require correction. If the designer(s)' review identifies no issue(s) with the ETL code **106** (see FIG. **1**) by determining that no objects listed in validation report **110** (see FIG. **1**) have any attribute with the red colored background or other visual indicator of a standards violation, then the No branch of step **212** is taken and step **214** is performed.

In an alternate embodiment, if none of the objects in validation report **110** (see FIG. **1**) includes the visual indicator of a standards violation and if the partially manual review does not find any issues with the additional information in validation report **110** (see FIG. **1**), as described below in the Partially Manual Review section, then ETL code **106** (see FIG. **1**) does not have any issues that require correction, the No branch of step **212** is taken and step **214** is performed.

In step **214**, based on validation report **110** (see FIG. **1**) not having any indicator of standard violations as determined by the designer(s)' review, the designer(s) formally approve the ETL code **106** (see FIG. **1**). Subsequent to step **214** and prior to step **216**, validation tool **104** (see FIG. **1**) receives an indication of the approval of the ETL code **106** (see FIG. **1**).

In an alternative embodiment, in step **214**, based on validation report **110** (see FIG. **1**) not having any indicator of standard violations as determined by the designer(s)' review and the partially manual review not finding any issues with the additional information in validation report **110** (see FIG. **1**), as described below in the Partially Manual Review section, the designer(s) formally approve the ETL code **106** (see FIG. **1**).

In step **216**, job definition file(s) (e.g., file in DSX format) specifying the ETL code **106** (see FIG. **1**) is imported to computer **102** (see FIG. **1**) or another computer (not shown) in a Quality Assurance (QA) environment.

Prior to step **218**, computer **102** (see FIG. **1**) or another computer (not shown) attempts to run the ETL code **106** (see FIG. **1**) end-to-end and the results are reviewed by experts in the QA environment. In step **218**, if the review in the QA environment identifies no issue(s) with the ETL code **106** (see FIG. **1**) by a review of the results of the end-to-end run, then the No branch of step **218** is taken and step **220** is performed.

In step **220**, computer **102** (see FIG. **1**) generates release notes associated with the ETL code **106** (see FIG. **1**) and releases the ETL code **106** (see FIG. **1**) and the release notes. Following step **220**, the process of FIG. **2** ends at step **222**.

Returning to step **218**, if the review in the QA environment identifies issue(s) with the ETL code **106** (see FIG. **1**) that need to be corrected or otherwise addressed, then the Yes branch of step **218** is taken and step **224** is performed. In step **224**, the designer(s) rework the ETL code **106** (see FIG. **1**) in the development environment to correct the issue(s) and the process loops back to step **202** to export the reworked ETL code **106** (see FIG. **1**) to job definition file(s). In the subsequent iteration of steps **202**, **204**, **206**, **208**, **210**, **212**, and **214**, the ETL code **106** (see FIG. **1**) is replaced with the reworked ETL code **106** (see FIG. **1**) resulting from the most recent performance of step **224**.

Returning to step **212**, if the designer(s)' review identifies issue(s) with the ETL code **106** (see FIG. **1**) that need to be corrected or otherwise addressed, then the Yes branch of step **212** is taken and step **224** is performed. In step **224** following the Yes branch of step **212**, the designer(s) rework the ETL code **106** (see FIG. **1**) in the development environment to correct the identified issue(s) and the process loops back to step **202** to export the reworked ETL code **106** (see FIG. **1**) to job definition file(s). In the subsequent iteration of steps **202**, **204**, **206**, **208**, **210**, and **212** (and step **214** if the No branch of step **212** is taken in the subsequent iteration), the ETL code **106** (see FIG. **1**) is replaced with the reworked ETL code **106** (see FIG. **1**) resulting from the most recent performance of step **224**.

In an alternate embodiment, returning to step **212**, if (1) the designer(s)' review identifies issue(s) with the ETL code **106** (see FIG. **1**) based on standard violation indicators in validation report **110** (see FIG. **1**), or if the partially manual review finds issue(s) with the additional information in validation report **110** (see FIG. **1**), as described below in the Partially Manual Review section, then the Yes branch of step **212** is taken and step **224** is performed. In step **224** following the Yes branch of step **212**, the designer(s) rework the ETL code **106** (see FIG. **1**) in the development environment to correct the identified issue(s) and the process loops back to step **202** to export the reworked ETL code **106** (see FIG. **1**) to job definition file(s). In the subsequent iteration of steps **202**, **204**, **206**, **208**, **210**, and **212** (and step **214** if the No branch of step **212** is taken in the subsequent iteration), the ETL code **106** (see FIG. **1**) is replaced with the reworked ETL code **106** (see FIG. **1**) resulting from the most recent performance of step **224**.

Partially Manual Review

In one embodiment, the review in step **212** (see FIG. **2**) includes a partially manual review that uses additional information included in validation report **110** (see FIG. **1**). The partially manual review checks (1) parameters from all objects (i.e., all jobs, sequences and routines) specified by ETL code **106** (see FIG. **1**), (2) file names referred to in different jobs from all kinds of file stages, (3) queries from all database stages, (4) parameters passed to job activities in different sequences, (5) job subroutines, (6) format of emails from all mail activities, including the body of the email and attachment(s) to the email, (7) all expressions from transformers including stage variables, output links, and loop variables, and (8) job full description along with the last modified timestamp of the job, which helps to verify job history. The aforementioned checks (1)-(8) are described below.

In the check of the parameters from all objects specified by ETL code **106**, a reviewer views a list of parameters defined on jobs, sequences and routines, along with the type of parameter and the default value set, to (1) verify consistency in naming of similar parameters across ETL projects, (2) identify redundant parameters, (3) verify type of parameters and default values, and (4) verify parameters defined on routines.

In the check of the file names referred to in different jobs from all kinds of file stages, a reviewer views a list of all the different files used in parallel jobs specified by ETL code **106** (see FIG. **1**), along with a type of the file (i.e., sequential, dataset, file set, lookup file set, or surrogate key state file), whether each instance is a read or write operation, and whether each instance is a SKG state file, to (1) check if all the files read are written somewhere in the system, (2) identify typographical errors in file names, and (3) during debugging, identify where a file is written or read instead of traversing through sequences.

In the check of queries from all database stages, a reviewer views a list of queries from all the parallel jobs specified by ETL code **106** (see FIG. **1**), along with query types (e.g., before query or after query), write mode (e.g., insert, update, or read), and table action (e.g., append or truncate), to (1) verify that each query has proper clauses and structure, (2) check if queries are performance effective, (3) check if the write mode is "append," "truncate," etc. at appropriate places, and (4) check if update queries have only primary keys in the "where" clause.

In the check of parameters passed to job activities in different sequences, a reviewer views a list of all job activities in every sequence specified by ETL code **106** (see

FIG. **1**), along with corresponding job names, all parameters of every job activity listed separately together with the values passed, and flags indicating whether the values are directly passed from the sequence parameters to (1) check if appropriate values are passed for parameters in each job activity, (2) validate the values passed when the flag is "false" (i.e., value is not directly passed from the parameter) to facilitate detection of any hardcoded values that are passed to the job, and (3) determine which sequence(s) are invoking a particular job.

In the check of job subroutines, a reviewer views a list of after subroutines and before subroutines for every parallel job specified by ETL code **106** (see FIG. **1**) to check if the correct subroutines are invoked in each job and to facilitate a review of routines of a significant number (e.g., hundreds) of jobs.

In the check of the format of emails from all mail activities, a reviewer views the subject, sender address, recipient list, attachments, and body of each mail activity to (1) check for proper structure of the message in the email body, (2) check for accuracy of the subject, (3) check whether attachments are present in cases where attachments are expected and whether the attachments refer to the appropriate files, (4) check whether the sender and recipient list are as expected, and (5) check that only mails that indicate an aborted job have a job report indicated.

In the check of all expressions from transformers including stage variables, output links, and loop variables, a reviewer views expressions from transformers whenever a direct mapping is not present, along with expressions of links, stage variables and loop variables to (1) check the accuracy of the expressions, (2) check for performance effectiveness of the expressions, and (3) verifying that the correct parameters are passed when parallel routines are being invoked.

In the check of job full description, a reviewer views a list of the job full descriptions of every job along with the timestamp of the last modification of the job to (1) verify that job change history is present, (2) use the date modified to verify that a history log is present for the latest change, and (3) check whether the change description is accurate, meaningful, and properly structured.

EXAMPLES

FIG. **3** depicts an exemplary portion **300** of validation report **110** (see FIG. **1**) summarizing violations of standards determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention. Portion **300** includes a section **302** including a list of parallel jobs and a section **304** including a list of sequence jobs, which are determined by validation tool **104** (see FIG. **1**).

Section **302** includes object-specific information for each job, including a job name, aggregator count, transformer count, re-partitioning count, sort count, annotation count, database read/write count, file read/write count, hardcoding count (i.e., count of the number of instances of hardcoding for each job), and standards violation count.

For example, for the second row of data in section **302**, the job name is AIE001WriteSAPFile, the aggregator count is 8, the transformer count is 6, the re-partitioning count is 6, the sort count is 7, the annotation count ratio is 22, the database read/write count is 3, the file read/write count is 5, the hardcoding count is 0, and the standards violation count is 59.

Although not shown in FIG. **3**, an indicator of a red colored background is present for the items that exceed corresponding threshold values. For example, in the second row of data in section **302**, the aggregator count, transformer count, re-partitioning count, sort count, annotation count ratio, and standards violation count exceed predetermined thresholds of 1, 1, 1, 1, 2, and 0, respectively. Therefore, each of the aggregator count, transformer count, re-partitioning count, sort count, annotation count ratio, and standards violation count has a red colored background to indicate a standards violation. Furthermore, the job name of AIE001WriteSAPFile has a red colored background to indicate the job has at least one standards violation and/or at least one hardcoding violation.

FIG. **4** is an exemplary portion **400** of validation report **110** (see FIG. **1**) indicating hardcoding violations determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention. Portion **400** includes a list of hardcoding violations determined by validation tool **104** (see FIG. **1**), where each hardcoding violation is identified by DSX line number, object type, object name, stage name, error description, string looked for, and DSX line.

For example, the first row of data in portion **400** indicates that for a parallel job having the name ATL201FileReceipt, validation tool **104** (see FIG. **1**) detects a database hardcoding violation because validation tool **104** (see FIG. **1**) finds the string SOL2DEV (see the string in the String Looked For column in portion **400**) in a DSX line of the parallel job ATL201FIleReceipt. A portion of the DSX line that includes "sol2dev" is shown in the DSX Line column in FIG. **4**. Regarding the second row of data in portion **400**, although the DWH_D string in the String Looked For column is not shown in the portion of the DSX line included in the DSX Line column, validation tool **104** (see FIG. **1**) finds the string DWH_D in a search of the entire DSX line, thereby detecting a hardcoding violation.

FIG. **5** is an exemplary portion **500** of validation report **110** (see FIG. **1**) indicating standards violations determined by the process of FIG. **2**, where the report is generated by the system of FIG. **1**, in accordance with embodiments of the present invention. Portion **500** includes a list of standards violations determined by validation tool **104** (see FIG. **1**). Each violation in the list of standards violations includes a DSX line number, object type, object name, stage name, stage type, violation type and violation description.

For example, the first row of data in portion **500** indicates that for the parallel job AIE001WriteSAPFile, validation tool **104** (see FIG. **1**) determines an annotation violation because there is no job annotation for AIE001WriteSAPFile.

Computer System

FIG. **6** is a block diagram of a computer that is included in the system of FIG. **1** and that implements the process of FIG. **2**, in accordance with embodiments of the present invention. Computer **102** is a computer system or mobile computing device that generally includes a central processing unit (CPU) **602**, a memory **604**, an input/output (I/O) interface **606**, and a bus **608**. Further, computer **102** is coupled to I/O devices **610** and a computer data storage unit **612**. CPU **602** performs computation and control functions of computer **102**, including carrying out instructions included in program code **614** to perform a method of validating code of an ETL tool, where the instructions are carried out by CPU **602** via memory **604**. CPU **602** may include a single processing unit, or be distributed across one or more processing units in one or more locations (e.g., on

a client and server). Program code **614** includes program code for validation tool **104** (see FIG. **1**).

Memory **604** includes a known computer readable storage medium, which is described below. In one embodiment, cache memory elements of memory **604** provide temporary storage of at least some program code (e.g., program code **614**) in order to reduce the number of times code must be retrieved from bulk storage while instructions of the program code are carried out. Moreover, similar to CPU **602**, memory **604** may reside at a single physical location, including one or more types of data storage, or be distributed across a plurality of physical systems in various forms. Further, memory **604** can include data distributed across, for example, a local area network (LAN) or a wide area network (WAN).

I/O interface **606** includes any system for exchanging information to or from an external source. I/O devices **610** include any known type of external device, including a display device, keyboard, etc. Bus **608** provides a communication link between each of the components in computer **102**, and may include any type of transmission link, including electrical, optical, wireless, etc.

I/O interface **606** also allows computer **102** to store information (e.g., data or program instructions such as program code **614**) on and retrieve the information from computer data storage unit **612** or another computer data storage unit (not shown). Computer data storage unit **612** includes a known computer-readable storage medium, which is described below. In one embodiment, computer data storage unit **612** is a non-volatile data storage device, such as a magnetic disk drive (i.e., hard disk drive) or an optical disc drive (e.g., a CD-ROM drive which receives a CD-ROM disk).

Memory **604** and/or storage unit **612** may store computer program code **614** that includes instructions that are carried out by CPU **602** via memory **604** to validate code of an ETL tool. Although FIG. **6** depicts memory **604** as including program code **614**, the present invention contemplates embodiments in which memory **604** does not include all of code **614** simultaneously, but instead at one time includes only a portion of code **614**.

Further, memory **604** includes an operating system (not shown) and may include other systems not shown in FIG. **6**.

Storage unit **612** and/or one or more other computer data storage units (not shown) that are coupled to computer **102** may include data store **108** (see FIG. **1**).

As will be appreciated by one skilled in the art, in a first embodiment, the present invention may be a system; in a second embodiment, the present invention may be a method; and in a third embodiment, the present invention may be a computer program product.

Any of the components of an embodiment of the present invention can be deployed, managed, serviced, etc. by a service provider that offers to deploy or integrate computing infrastructure with respect to validating code of an ETL tool. Thus, an embodiment of the present invention discloses a process for supporting computer infrastructure, where the process includes providing at least one support service for at least one of integrating, hosting, maintaining and deploying computer-readable code (e.g., program code **614**) in a computer system (e.g., computer **102**) including one or more processors (e.g., CPU **602**), wherein the processor(s) carry out instructions contained in the code causing the computer system to validate code of an ETL tool. Another embodiment discloses a process for supporting computer infrastructure, where the process includes integrating computer-readable program code into a computer system including a processor. The step of integrating includes storing the program code in a computer-readable storage device of the computer system through use of the processor. The program code, upon being executed by the processor, implements a method of validating code of an ETL tool.

While it is understood that program code **614** for validating code of an ETL tool may be deployed by manually loading directly in client, server and proxy computers (not shown) via loading a computer-readable storage medium (e.g., computer data storage unit **612**), program code **614** may also be automatically or semi-automatically deployed into computer **102** by sending program code **614** to a central server or a group of central servers. Program code **614** is then downloaded into client computers (e.g., computer **102**) that will execute program code **614**. Alternatively, program code **614** is sent directly to the client computer via e-mail. Program code **614** is then either detached to a directory on the client computer or loaded into a directory on the client computer by a button on the e-mail that executes a program that detaches program code **614** into a directory. Another alternative is to send program code **614** directly to a directory on the client computer hard drive. In a case in which there are proxy servers, the process selects the proxy server code, determines on which computers to place the proxy servers' code, transmits the proxy server code, and then installs the proxy server code on the proxy computer. Program code **614** is transmitted to the proxy server and then it is stored on the proxy server.

Another embodiment of the invention provides a method that performs the process steps on a subscription, advertising and/or fee basis. That is, a service provider, such as a Solution Integrator, can offer to create, maintain, support, etc. a process of validating code of an ETL tool. In this case, the service provider can create, maintain, support, etc. a computer infrastructure that performs the process steps for one or more customers. In return, the service provider can receive payment from the customer(s) under a subscription and/or fee agreement, and/or the service provider can receive payment from the sale of advertising content to one or more third parties.

The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) (memory **604** and computer data storage unit **612**) having computer readable program instructions **614** thereon for causing a processor (e.g., CPU **602**) to carry out aspects of the present invention.

The computer readable storage medium (i.e., computer readable storage device) can be a tangible device that can retain and store instructions (e.g., program code **614**) for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium and a computer

readable storage device, as used herein, are not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions (e.g., program code **614**) described herein can be downloaded to respective computing/processing devices (e.g., computer **102**) from a computer readable storage medium or to an external computer or external storage device (e.g., computer data storage unit **612**) via a network (not shown), for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card (not shown) or network interface (not shown) in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions (e.g., program code **614**) for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

Aspects of the present invention are described herein with reference to flowchart illustrations (e.g., FIG. **2**) and/or block diagrams (e.g., FIG. **1** and FIG. **6**) of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions (e.g., program code **614**).

These computer readable program instructions may be provided to a processor (e.g., CPU **602**) of a general purpose computer, special purpose computer, or other programmable data processing apparatus (e.g., computer **102**) to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium (e.g., computer data storage unit **612**) that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions (e.g., program code **614**) may also be loaded onto a computer (e.g. computer **102**), other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

While embodiments of the present invention have been described herein for purposes of illustration, many modifications and changes will become apparent to those skilled in the art. Accordingly, the appended claims are intended to encompass all such modifications and changes as fall within the true spirit and scope of this invention.

What is claimed is:

1. A method of validating code of an extract, transform and load (ETL) tool, the method comprising the steps of:

responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code of the ETL tool to a job definition file, a computer parsing the code of the ETL tool in the job definition file;

the computer determining violations of the naming, coding, and performance standards in part by determining the parsed code of the ETL tool does not match the naming, coding, and performance standards;

the computer generating a report which identifies the violations;

based at least in part on a review of the report and a rework of the code of the ETL tool to comply with the naming, coding and performance standards and responsive to an export of the reworked code of the ETL tool

to another job definition file, the computer parsing the reworked code of the ETL tool in the other job definition file, determining that the parsed reworked code of the ETL tool does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code of the ETL tool does not include the violations;

the computer receiving maximum numbers of aggregator stages of a job included in the code of the ETL tool, transformer stages of the job, occurrences of repartitioning of data sets in the job, sort stages of the job, database read/write operations of the job, and sequential file read/write operations of the job;

the computer receiving a minimum ratio of a number of stages of the job to a number of stages of the job that are annotated;

the computer receiving minimum sizes of a transaction for any insert, update or delete operation of the job and an array employed for any insert, update or delete operation of the job; and

based on aggregator stages of the job exceeding the maximum number of aggregator stages, transformer stages of the job exceeding the maximum number of transformer stages of the job, occurrences of repartitioning of data sets in the job exceeding the maximum number of occurrences of repartitioning of data sets in the job, sort stages of the job exceeding the maximum number of sort stages, database read/write operations of the job exceeding the maximum number of database read/write operations, sequential file read/write operations of the job exceeding the maximum number of sequential file read/write operations, a ratio of the number of stages of the job to the number of stages of the job that are annotated being less than the minimum ratio of the number of stages to the number of stages that are annotated, a size of a transaction for an insert, update or delete operation of the job being less than the minimum size of the transaction, or a size of an array employed for an insert, update or delete operation of the job being less than the minimum size of the array, the computer determining a violation of a performance standard included in the naming, coding, and performance standards.

2. The method of claim **1**, further comprising the steps of:

the computer sending the other job definition file of the approved reworked code of the ETL tool to a quality assurance (QA) environment;

in response to a second rework of the code of the ETL tool based on the other job definition, the computer exporting the code of the ETL tool resulting from the second rework to yet another job definition file, parsing the code of the ETL tool resulting from the second rework, determining that the code of the ETL tool resulting from the second rework does not include the violations of the naming, coding and performance standards, generating a third report that indicates that the code of the ETL tool resulting from the second rework does not include the violations, receiving an approval of the code of the ETL tool resulting from the second rework, and sending a job definition file of the approved code of the ETL tool resulting from the second rework to the QA environment;

the computer receiving an indication of a successful end-to-end run of the ETL tool based on the approved code of the ETL tool resulting from the second rework; and

based on the received indication of the successful end-to-end run of the ETL tool, the computer generating release notes for the approved code of the ETL tool resulting from the second rework.

3. The method of claim **1**, further comprising the steps of:

the computer determining the code of the ETL tool matches a regular expression specified by a coding standard included in the naming, coding, and performance standards; and

based on the code of the ETL tool matching the regular expression, the computer determining the code of the ETL tool includes hardcoding, wherein the step of generating the report includes generating the report which identifies the hardcoding, wherein the step of generating the second report is based in part on a rework of the code of the ETL tool to eliminate the hardcoding, and wherein the second report indicates the reworked code of the ETL tool does not include the hardcoding.

4. The method of claim **1**, further comprising the steps of:

the computer determining a name of an object included in the code of the ETL tool;

the computer determining a naming standard of the object includes a regular expression or a sequence of characters that is not a regular expression, the naming standard included in the naming, coding, and performance standards;

if the naming standard of the object includes a regular expression, the computer determining a name of the object does not match the regular expression, or if the naming standard of the object includes the sequence of characters, the computer determining the name of the object does not begin with the sequence of characters; and

based on the name of the object not matching the regular expression or not beginning with the sequence of characters, the computer determining a violation of the naming standard, which is included in the violations of the naming, coding, and performance standards.

5. The method of claim **1**, further comprising the step of the computer determining job names, stage names, stage types, violation types, and descriptions of the violations, wherein the step of generating the report includes generating the report to include the job names, stage names, stage types, violation types and descriptions of the violations.

6. The method of claim **1**, further comprising the step of:

providing at least one support service for at least one of creating, integrating, hosting, maintaining, and deploying computer-readable program code in the computer system, the program code being executed by a processor of the computer system to implement the steps of parsing the code of the ETL tool, determining the violations, generating the report, parsing the reworked code of the ETL tool, determining that the parsed reworked code of the ETL tool does not include the violations, generating the second report, receiving the maximum numbers of the aggregator stages of the job, the transformer stages of the job, the occurrences of the repartitioning of the data sets, the sort stages of the job, the database read/write operations, and the sequential file read/write operations, receiving the minimum ratio of the number of stages of the job to the number of stages of the job that are annotated, receiving the minimum sizes of the transaction for any insert, update or delete operation of the job and the array employed for any insert, update or delete operation of the job, and determining the violation of the performance standard.

7. A computer system comprising:
a central processing unit (CPU);
a memory coupled to the CPU; and
a computer-readable storage device coupled to the CPU, the storage device containing instructions that are executed by the CPU via the memory to implement a method of validating code of an extract, transform and load (ETL) tool, the method comprising the steps of:
responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code of the ETL tool to a job definition file, the computer system parsing the code of the ETL tool in the job definition file;
the computer system determining violations of the naming, coding, and performance standards in part by determining the parsed code of the ETL tool does not match the naming, coding, and performance standards;
the computer system generating a report which identifies the violations;
based at least in part on a review of the report and a rework of the code of the ETL tool to comply with the naming, coding and performance standards and responsive to an export of the reworked code of the ETL tool to another job definition file, the computer system parsing the reworked code of the ETL tool in the other job definition file, determining that the parsed reworked code of the ETL tool does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code of the ETL tool does not include the violations;
the computer system receiving maximum numbers of aggregator stages of a job included in the code of the ETL tool, transformer stages of the job, occurrences of repartitioning of data sets in the job, sort stages of the job, database read/write operations of the job, and sequential file read/write operations of the job;
the computer system receiving a minimum ratio of a number of stages of the job to a number of stages of the job that are annotated;
the computer system receiving minimum sizes of a transaction for any insert, update or delete operation of the job and an array employed for any insert, update or delete operation of the job; and
based on aggregator stages of the job exceeding the maximum number of aggregator stages, transformer stages of the job exceeding the maximum number of transformer stages of the job, occurrences of repartitioning of data sets in the job exceeding the maximum number of occurrences of repartitioning of data sets in the job, sort stages of the job exceeding the maximum number of sort stages, database read/write operations of the job exceeding the maximum number of database read/write operations, sequential file read/write operations of the job exceeding the maximum number of sequential file read/write operations, a ratio of the number of stages of the job to the number of stages of the job that are annotated being less than the minimum ratio of the number of stages to the number of stages that are annotated, a size of a transaction for an insert, update or delete operation of the job being less than the minimum size of the transaction, or a size of an array employed for an insert, update or delete operation of the job being less than the minimum size of the array, the computer system determining a violation of a performance standard included in the naming, coding, and performance standards.

8. The computer system of claim 7, wherein the method further comprises the steps of:
the computer system sending the other job definition file of the approved reworked code of the ETL tool to a quality assurance (QA) environment;
in response to a second rework of the code of the ETL tool based on the other job definition, the computer system exporting the code of the ETL tool resulting from the second rework to yet another job definition file, parsing the code of the ETL tool resulting from the second rework, determining that the code of the ETL tool resulting from the second rework does not include the violations of the naming, coding and performance standards, generating a third report that indicates that the code of the ETL tool resulting from the second rework does not include the violations, receiving an approval of the code of the ETL tool resulting from the second rework, and sending a job definition file of the approved code of the ETL tool resulting from the second rework to the QA environment;
the computer system receiving an indication of a successful end-to-end run of the ETL tool based on the approved code of the ETL tool resulting from the second rework; and
based on the received indication of the successful end-to-end run of the ETL tool, the computer system generating release notes for the approved code of the ETL tool resulting from the second rework.

9. The computer system of claim 7, wherein the method further comprises the steps of:
the computer system determining the code of the ETL tool matches a regular expression specified by a coding standard included in the naming, coding, and performance standards; and
based on the code of the ETL tool matching the regular expression, the computer system determining the code of the ETL tool includes hardcoding, wherein the step of generating the report includes generating the report which identifies the hardcoding, wherein the step of generating the second report is based in part on a rework of the code of the ETL tool to eliminate the hardcoding, and wherein the second report indicates the reworked code of the ETL tool does not include the hardcoding.

10. The computer system of claim 7, wherein the method further comprises the steps of:
the computer system determining a name of an object included in the code of the ETL tool;
the computer system determining a naming standard of the object includes a regular expression or a sequence of characters that is not a regular expression, the naming standard included in the naming, coding, and performance standards;
if the naming standard of the object includes a regular expression, the computer system determining a name of the object does not match the regular expression, or if the naming standard of the object includes the sequence of characters, the computer system determining the name of the object does not begin with the sequence of characters; and
based on the name of the object not matching the regular expression or not beginning with the sequence of characters, the computer system determining a viola-

tion of the naming standard, which is included in the violations of the naming, coding, and performance standards.

11. The computer system of claim **7**, wherein the method further comprises the step of the computer system determining job names, stage names, stage types, violation types, and descriptions of the violations, wherein the step of generating the report includes generating the report to include the job names, stage names, stage types, violation types and descriptions of the violations.

12. A computer program product, comprising:

a computer-readable storage device; and

a computer-readable program code stored in the computer-readable storage device, the computer-readable program code containing instructions that are executed by a central processing unit (CPU) of a computer system to implement a method of validating code of an extract, transform and load (ETL) tool, the method comprising the steps of:

responsive to a receipt of naming, coding, and performance standards for the code of the ETL tool and an export of the code of the ETL tool to a job definition file, the computer system parsing the code of the ETL tool in the job definition file;

the computer system determining violations of the naming, coding, and performance standards in part by determining the parsed code of the ETL tool does not match the naming, coding, and performance standards;

the computer system generating a report which identifies the violations;

based at least in part on a review of the report and a rework of the code of the ETL tool to comply with the naming, coding and performance standards and responsive to an export of the reworked code of the ETL tool to another job definition file, the computer system parsing the reworked code of the ETL tool in the other job definition file, determining that the parsed reworked code of the ETL tool does not include the violations of the naming, coding and performance standards, and generating a second report that indicates that the reworked code of the ETL tool does not include the violations;

the computer system receiving maximum numbers of aggregator stages of a job included in the code of the ETL tool, transformer stages of the job, occurrences of repartitioning of data sets in the job, sort stages of the job, database read/write operations of the job, and sequential file read/write operations of the job;

the computer system receiving a minimum ratio of a number of stages of the job to a number of stages of the job that are annotated;

the computer system receiving minimum sizes of a transaction for any insert, update or delete operation of the job and an array employed for any insert, update or delete operation of the job; and

based on aggregator stages of the job exceeding the maximum number of aggregator stages, transformer stages of the job exceeding the maximum number of transformer stages of the job, occurrences of repartitioning of data sets in the job exceeding the maximum number of occurrences of repartitioning of data sets in the job, sort stages of the job exceeding the maximum number of sort stages, database read/write operations of the job exceeding the maximum number of database read/write operations, sequential file read/write operations of the job exceeding the maximum number of sequential file read/write operations, a ratio of the number of stages of the job to the number of stages of the job that are annotated being less than the minimum ratio of the number of stages to the number of stages that are annotated, a size of a transaction for an insert, update or delete operation of the job being less than the minimum size of the transaction, or a size of an array employed for an insert, update or delete operation of the job being less than the minimum size of the array, the computer system determining a violation of a performance standard included in the naming, coding, and performance standards.

13. The computer program product of claim **12**, wherein the method further comprises the steps of:

the computer system sending the other job definition file of the approved reworked code of the ETL tool to a quality assurance (QA) environment;

in response to a second rework of the code of the ETL tool based on the other job definition, the computer system exporting the code of the ETL tool resulting from the second rework to yet another job definition file, parsing the code of the ETL tool resulting from the second rework, determining that the code of the ETL tool resulting from the second rework does not include the violations of the naming, coding and performance standards, generating a third report that indicates that the code of the ETL tool resulting from the second rework does not include the violations, receiving an approval of the code of the ETL tool resulting from the second rework, and sending a job definition file of the approved code of the ETL tool resulting from the second rework to the QA environment;

the computer system receiving an indication of a successful end-to-end run of the ETL tool based on the approved code of the ETL tool resulting from the second rework; and

based on the received indication of the successful end-to-end run of the ETL tool, the computer system generating release notes for the approved code of the ETL tool resulting from the second rework.

14. The computer program product of claim **12**, wherein the method further comprises the steps of:

the computer system determining the code of the ETL tool matches a regular expression specified by a coding standard included in the naming, coding, and performance standards; and

based on the code of the ETL tool matching the regular expression, the computer system determining the code of the ETL tool includes hardcoding, wherein the step of generating the report includes generating the report which identifies the hardcoding, wherein the step of generating the second report is based in part on a rework of the code of the ETL tool to eliminate the hardcoding, and wherein the second report indicates the reworked code of the ETL tool does not include the hardcoding.

15. The computer program product of claim **12**, wherein the method further comprises the steps of:

the computer system determining a name of an object included in the code of the ETL tool;

the computer system determining a naming standard of the object includes a regular expression or a sequence of characters that is not a regular expression, the naming standard included in the naming, coding, and performance standards;

if the naming standard of the object includes a regular expression, the computer system determining a name of the object does not match the regular expression, or if the naming standard of the object includes the sequence of characters, the computer system determining the name of the object does not begin with the sequence of characters; and

based on the name of the object not matching the regular expression or not beginning with the sequence of characters, the computer system determining a violation of the naming standard, which is included in the violations of the naming, coding, and performance standards.

16. The computer program product of claim **12**, wherein the method further comprises the step of the computer system determining job names, stage names, stage types, violation types, and descriptions of the violations, wherein the step of generating the report includes generating the report to include the job names, stage names, stage types, violation types and descriptions of the violations.

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